

# Study of Higher Order Net-Particle Fluctuations at LHC Energies\*

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Higher moments of net-particle fluctuations are used to study the QCD phase structure of matter which is created in high-energy heavy-ion collisions. Theoretically, the fluctuations of net-charge, net-baryon, and net-strangeness distributions allow to explore the QCD phase diagram, including the search for a critical point and the cross-over transition. Experimentally, they are accessible via higher order moments of those distributions, expressed in cumulants  $c_k$  and their ratios of net-charge, net-proton, and net-kaon fluctuations, eg. the 4th order moment  $\kappa = c_4/c_2^2$ , see [1]. At LHC energies, these measurements allow to test Lattice QCD calculations at zero chemical potential ( $\mu_B = 0$ ) [2].

Experimental measurements are influenced by detector effects, such as limited detector acceptance, reconstruction and particle identification inefficiencies, as well as contamination from miss-identified particles. Typically inefficiencies are fluctuating due to detector inhomogeneities and can not be corrected on an event-by-event basis, but rather on average. Recent developments take these effects into account by calculating factorial moments for the so-called K-cumulants [3]. The typical available statistics of recorded heavy-ion collisions at LHC experiments impose limitations on the observables, which are possible to calculate.

A Toy Monte-Carlo simulation was developed, assuming Poisson statistics for particle and anti-particle distributions, mimicking a Hadron Resonance Gas (HRG) distribution and a finite reconstruction and identification efficiency. The difference of two Poissonian distributions is described by a Skellam distribution, the net-particle distribution. The mean of the particle and anti-particle distributions, as well as the efficiencies are variable input parameters for this simulation. The reconstruction efficiency is assumed independent of the transverse momentum  $p_T$ . In general the efficiencies are dependent on  $p_T$ . These dependences are taken into account in [4] and will be studied further within the context of this work.

To study the influence on the observables of the number of simulated events, several independent samples with varying number of events have been produced in steps from  $10^5$  to  $10^9$  events. Furthermore, the efficiencies have been varied in 10% steps in the range of 20-100%.

The results of these simulations with different efficiencies for cumulants and efficiency corrected K-cumulants have been compared to the expected values from the generated particles as well as analytical calculations.

It can be seen in Figure 1, that the 4th order moment  $\kappa$  obtained from cumulants of reconstructed particles agrees with the analytical value after the efficiency corrections for K-cumulants are applied. It was found that for a mean number of particles/anti-particles ( $M = 40$ ) a minimum of  $5 \cdot 10^7$  events are required in order to estimate the 4th order moment.

The above describe procedure will be applied to LHC data, in particular to the experimental data of the upcoming high-statistics RUN 2.

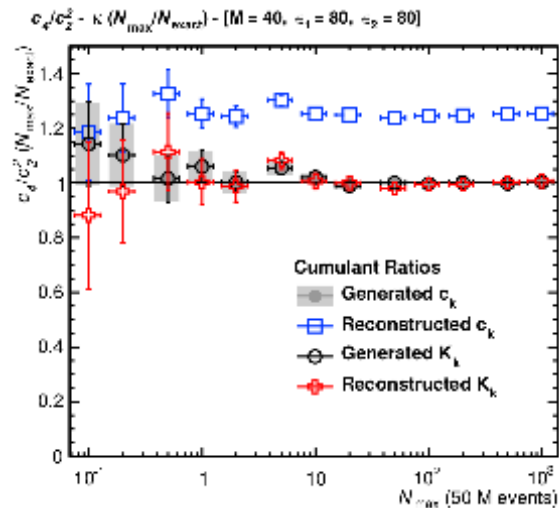


Figure 1: Ratio of the calculated  $\kappa$  to the exact value obtained from the Skellam distribution for a reconstruction efficiency  $\epsilon_{1,2} = 80\%$  of each particle and anti-particle type and a mean of 40 (anti-)particles per event. The open and closed circles show  $\kappa$  for generated particles, while the boxes (crosses) show  $\kappa$  for the reconstructed cumulants (K-cumulants) with different number of simulated events  $N_{\max}$ .

## References

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